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Future climate change RCP4.5 and RCP8.5 scenarios downscaling for the Northern Europe with the focus on the North and Baltic Seas.

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1. Model setup

The REgional atmosphere MOdel **REMO** (Jacob, 2001) with 37km resolution and 27 hybrid vertical levels is coupled to the global ocean – sea ice – marine biogeochemistry model **MPIOM/HAMOCC** (Marsland et al., 2003) with increased resolution on the North-West European Shelves (up to 4 km in the German Bight). The coupled domain includes Europe, the North-East Atlantic and part of the Arctic Ocean (Fig.1). The models are coupled via the **OASIS** coupler. In addition, the ocean model was run with ocean tides and better representation of the diurnal cycle (one hour coupled time step). The last two modifications make one of the major differences from the MPI-ESM CMIP5 simulations, where the diurnal cycle and tidal dynamics were neglected. The ocean tidal forcing was derived from the full ephemeridic luni-solar tidal potential. The global Hydrological Discharge model **HD**, which calculates river runoff (0.5º horizontal grid resolution), is coupled to both the atmosphere and ocean components.

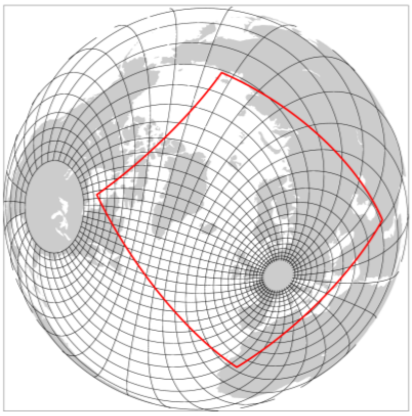

Figure 1. Grid configuration: the red "rectangle" indicates the coupled domain (REMO model) black lines indicate the grid of the MPIOM/HAMOCC. For the ocean/sea ice grid only every 15th line is shown.

Lateral atmospheric and upper oceanic boundary conditions outside the coupled domain were prescribed using MPI-ESM C20 20-th century, RCP4.5 and RCP8.5 scenarios data (the total simulation period was 1920-2005 + 2 x 2006-2100) for corresponding scenarios downscaling. The model was spun-up for the period 1920-2000. Then the **scenario** runs (21st century) and in parallel a **control** run (20th century forcing) were carried out.

2. Hindcast simulations with MPI-ESM forcing

The simulated mean winter 2m temperature (T2M) biases are shown on Fig.2. REMO/MPIOM and driving MPI-ESM show quite different behavior. Whereas MPI-ESM simulates better T2M in the North-eastern Europe, in other European regions, i.e. Central and Southern Europe REMO/MPIOM shows better results.

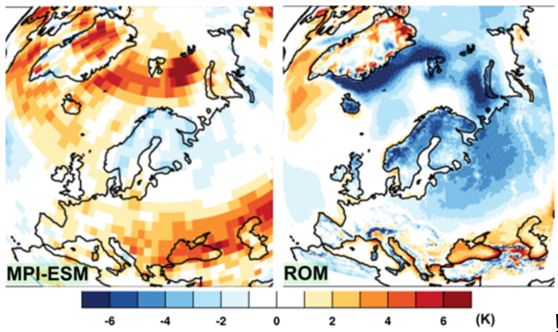

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Figure 2. Mean DJF 1980-2000 2m temperature difference (Model – ERA40) Left: MPI-ESM, Right: REMO/MPIOM.

The simulated sea surface temperature (SST) and sea surface salinity (SSS) biases are shown on Fig.3. The Climatology of the North Sea is represented quite well, but the simulated Baltic Sea is to cold (1-2K) and to salty (1-1.5psu). Higher salinity in the Baltic Sea can be explained by the overestimation of the water inflow from the North Sea.

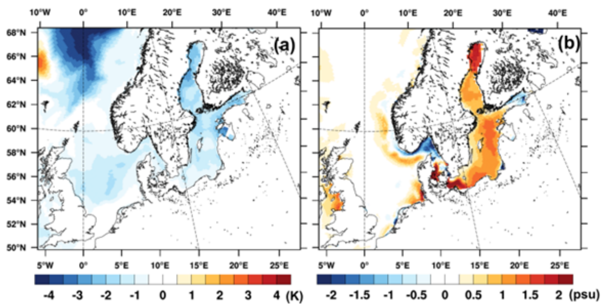

Figure 3. Annual mean 1980-2000 SST (left) and SSS (right) difference (Model – GDEM climatology)

The cold SST bias in both the North Sea and Baltic Seas is mainly caused by the cold atmospheric bias over the North-eastern Europe (Fig.2)

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3. Climate change. Atmosphere.

Changes in T2M and total precipitation are presented on the Fig.4. Whereas the Arctic amplification is seen in both the scenarios, the warming signal in RCP4.5 and RCP8.5 is different for the Europe. The stronger warming in case of RCP8.5 enhances the hydrological cycle in the Eastern Europe up to 20-50%.

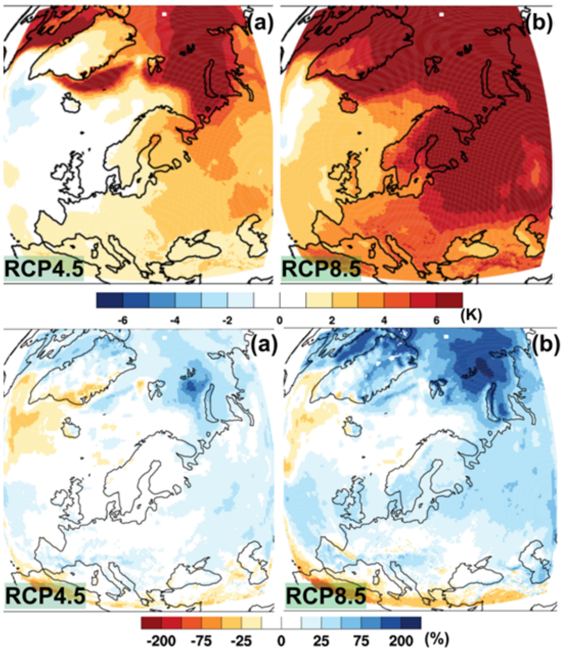

Figure 4. Mean DJF 2m temperature (upper) and relative precipitation (lower) change (2080-2099 – 1980-1999) obtained for RCP4.5 (left) and RCP8.5 (right)

4. Climate change. Ocean

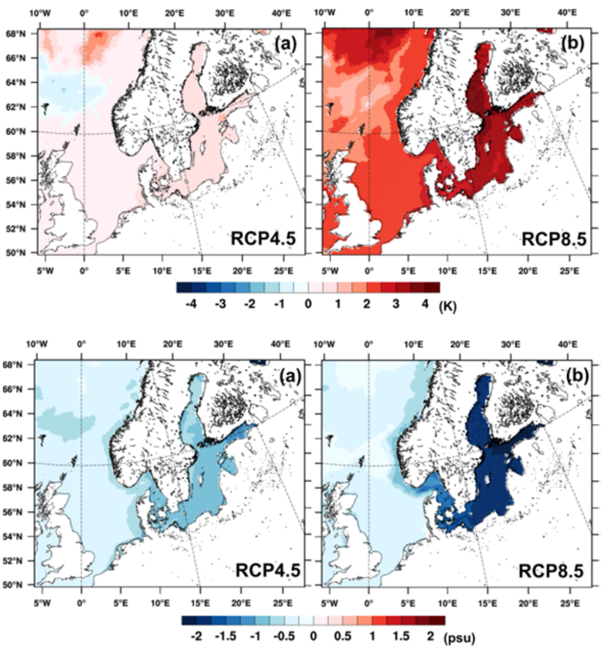

Figure 5. Annual mean SST (upper) and SSS (lower) differences (2080-2099 – 1980-1999) obtained for RCP4.5 (left) and RCP8.5 (right)

To analyze the climate changes in the Baltic and the North Sea regions we provide a comparison between two last decades of the 20th and 21st century for both the RCP4.5 and RCP8.5 scenarios (Fig.5). The warming is substantially different for both the scenarios. In case of RCP4.5 it is in the range of interdecadal variability. The simulated SST change by the end of the 21st century in case of RCP8.5 is much higher reaching up to 4K in the Baltic Sea.

The SSS change in the North Sea is relatively small similar for both the scenarios (Fig.4). In opposite, the changes in the Baltic Sea are much stronger pronounced in the case of RCP8.5. The freshening there reaches more than 2 psu.! The main reason for this freshening is the simulated increase of winter precipitation in the Baltic Sea catchment area.

5. Conclusions

The downscaled RCP4.5 scenario shows relatively small changes in the North and Baltic Seas. Both the SSS and SST changes (except of SSS in the Baltic) obtained by RCP4.5 simulations are in the range of interdecadal variability.

The most pronounced changes corresponding to downscaled RCP8.5 scenario projection for the North European shelves were obtained in the Baltic Sea. Global warming will affect the Baltic Sea primarily through an enhancement of the hydrological cycle which delivers more moisture from the tropics towards the poles. The resulting increase of precipitation over the Baltic Sea catchment area leads to substantial increase of the river runoff which is much stronger than in surrounding areas.

References

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